ANSWERS - AP Physics Multiple Choice Practice – Rotation

SECTION A – Torque and Statics

|  |  |  |
| --- | --- | --- |
|  | Solution | Answer |
|  | Definition of Torque | D |
|  | To balance the forces (Fnet=0) the answer must be A or D, to prevent rotation, obviously A would be needed | A |
|  | FBD T Since the rope is at an angle it has x and y components of force.  H Therefore, H would have to exist to counteract Tx.  W Based on Ʈnet = 0 requirement, V also would have V to exist to balance W if we were to chose a pivot point at the right end of the bar | B |
|  | Applying rotational equilibrium to each diagram gives  DIAGRAM 1: (mg)(L1) = (M1g)(L2) DIAGRAM 2: (M2g)(L1) = mg(L2)  L1 = M1(L2) /m M2 (L1) = m (L2)  (sub this L1) into the Diagram 2 eqn, and solve. | E |
|  | Find the torques of each using proper signs and add up. 2  + (1) – (2) + (3) + (4)  +F(3R) – (2F)(3R) + F(2R) +F(3R) = 2FR  3  1  4 | C |
|  | Simply apply rotational equilibrium  (m1g) • r1 = (m2g) • r2 m1a = m2b | B |

SECTION B – Rotational Kinematics and Dynamics

|  |  |  |
| --- | --- | --- |
|  | α=Δω/Δt | A |
|  | Krot = ½ Iω2 | B |
|  | ω = dθ/dt = 6t + 2; v = ωr | D |
|  | Itot = ΣI = I0 + IM = I0 + M(½L)2 | A |
|  | Στ = Iα where Στ = (3M0)(l) – (M0)(2l) = M0l and I = (3M0)(l)2 + (M0)(2l)2 = 7M0l 2 | A |
|  | τX = Fl; τO = FOLO sin θ, solve for the correct combination of FO and LO | C |
|  | Just as the tension in a rope is greatest at the bottom of as vertical circle, the force needed to maintain circular motion in any vertical circle is greatest at the bottom as the applied force must balance the weight of the object and additionally provide the necessary centripetal force | C |
|  | ΣFbottom = Fadhesion – mg = Fcentripetal = mω2r | E |
|  | For one complete revolution θ = 2π; ω2 = ω02 + 2αθ | C |
|  | The moment of inertia is least about the object’s center of mass. The greater the distance of the axis from the center of mass, the greater the moment of inertia (I = Icm + MD2). The center of mass is at point B. | E |
|  | τ = ΔL/Δt = (Iωf – 0)/T | E |
|  | Pavg = τωavg = (Iωf/T)(½ωf) or Pavg = ΔK/T | B |
|  | Στ = T2R – T1R = Iα | D |
|  | θ = ω0t + ½ αt2 | D |
|  | If the cylinder is “suspended in mid air” (i.e. the linear acceleration is zero) then ΣF = 0 | E |
|  | Στ = TR = Iα = ½ MR2α which gives α = 2T/MR and since ΣF = 0 then T = Mg so α = 2g/R  the acceleration of the person’s hand is equal to the linear acceleration of the string around the rim of the cylinder a = αR = 2g | B |
|  | In order that the mass not slide down *f* = μFN ≥ mg and FN = mω2R  solving for μ gives μ ≥ g/ω2R | B |

SECTION C – Rolling

|  |  |  |
| --- | --- | --- |
| 1. | Ktot = Krot + Ktrans = ½ Iω2 + ½ Mv2 = ½ (2/5)MR2ω2 + ½ Mv2 = (1/5)Mv2 + ½ Mv2 = (7/10)Mv2 = MgH, solving gives H = 7v2/10g | D |
| 2. | Rolling without slipping: v = ωR. Linear momentum = Mv = MωR | A |
| 3. | Mgh = Ktot = Krot + Ktrans, however without friction, there is no torque to cause the sphere to rotate so Krot = 0 and Mgh = ½ Mv2 | A |
| 4. | Mgh = Ktot = Krot + Ktrans = ½ Iω2 + ½ Mv2; substituting v/r for ω gives  Mgh = ½(I/r2 + M)v2 and solving for v gives v2 = 2Mgh/(I/r2 + M), multiplying by r2/r2 gives desired answer | E |
| 5. | v = d/t and ω = v/r | C |
| 6. | The first movement of the point of contact of a rolling object is vertically upward as there is no side to side (sliding) motion for the point in contact | A |

SECTION D – Angular Momentum

|  |  |  |
| --- | --- | --- |
| 1. | Li = Lf so IiωI = Ifωf and since If < Ii (mass more concentrated near axis), then ωf > ωi  The increase in ω is in the same proportion as the decrease in I, and the kinetic energy is proportional to Iω2 so the increase in ω results in an overall increase in the kinetic energy.  Alternately, the skater does work to pull their arms in and this work increases the KE of the skater | C |
| 2. | L = Iω | D |
| 3. | Li = Lf so IiωI = Ifωf and since If < Ii (mass more concentrated near axis), then ωf > ωi  The increase in ω is in the same proportion as the decrease in I, and the kinetic energy is proportional to Iω2 so the increase in ω results in an overall increase in the kinetic energy.  Alternately, the skater does work to pull their arms in and this work increases the KE of the skater | E |
| 4. | L = mvr⊥ where r⊥ is the perpendicular line joining the origin and the line along which the particle is moving | B |
| 5. | L = Iω and since ω is uniform the ratio Lupper/Llower = Iupper/Ilower = 2mL2/2(2m)(2L)2 = 1/8 | E |
| 6. | Since it is a perfectly inelastic (sticking) collision, KE is not conserved. As there are no external forces or torques, both linear and angular momentum are conserved | E |
| 7. | As there are no external forces or torques, both linear and angular momentum are conserved. As the type of collision is not specified, we cannot say kinetic energy *must* be the same. | C |
| 8. | Li = Lf so IiωI = Ifωf and since If < Ii (mass more concentrated near axis), then ωf > ωi  The increase in ω is in the same proportion as the decrease in I, and the kinetic energy is proportional to Iω2 so the increase in ω results in an overall increase in the kinetic energy.  Alternately, the skater does work to pull their arms in and this work increases the KE of the skater | C |